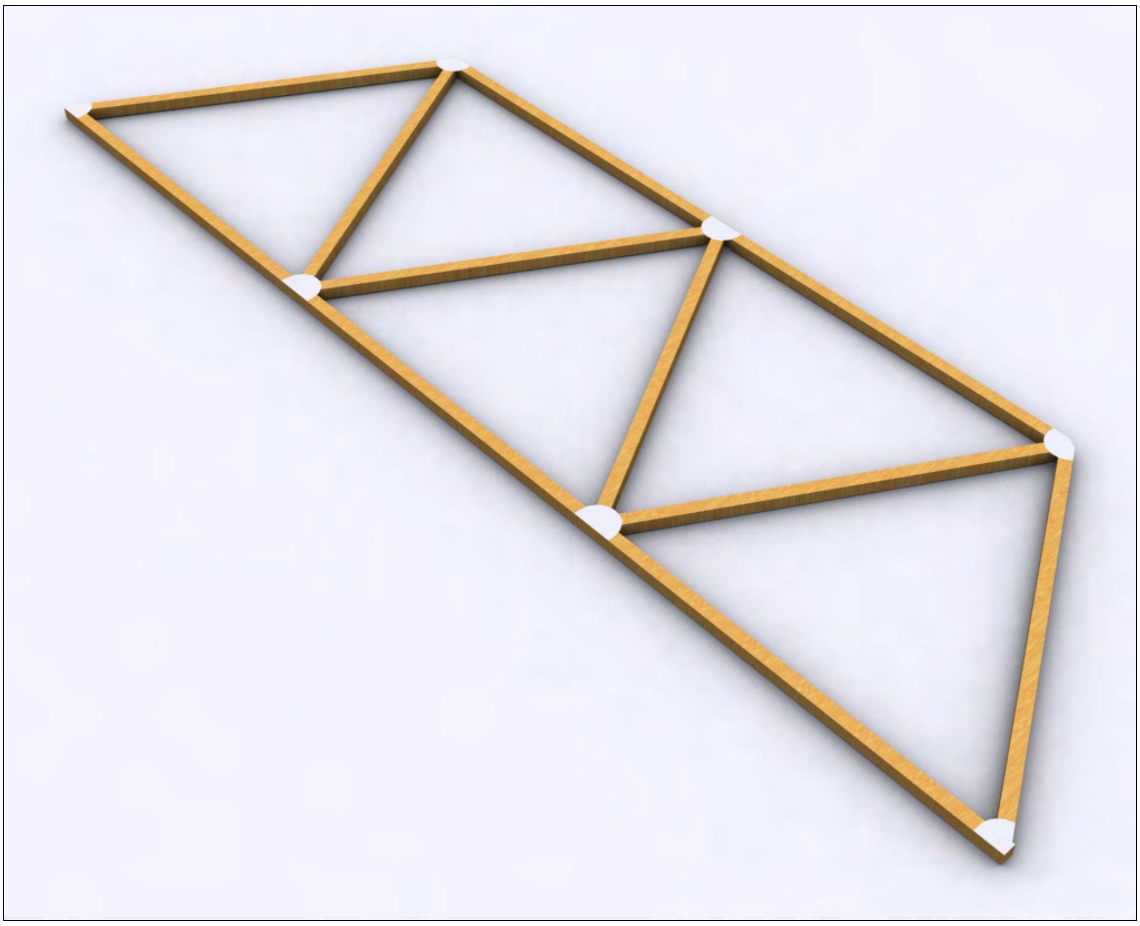
HSC ENGINEERING STUDIES

ASSESSMENT TASK 1

CIVIL STRUCTURES



ANDREW HARVEY

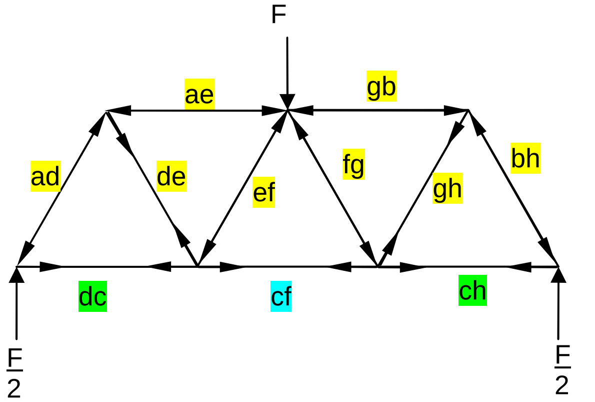
CONTENTS

REPORT BODY

Truss Design:

We used the first truss design, (See Appendix A & B). We chose this one because it had the lowest maximum force in any member, and therefore would take more load than design number two.

Analysis of Forces in all Members:



$$ad = ae = de = ef = fg = gb = bh = gh = \frac{F}{\sqrt{3}}$$

$$ch = dc = \frac{F}{2\sqrt{3}}$$

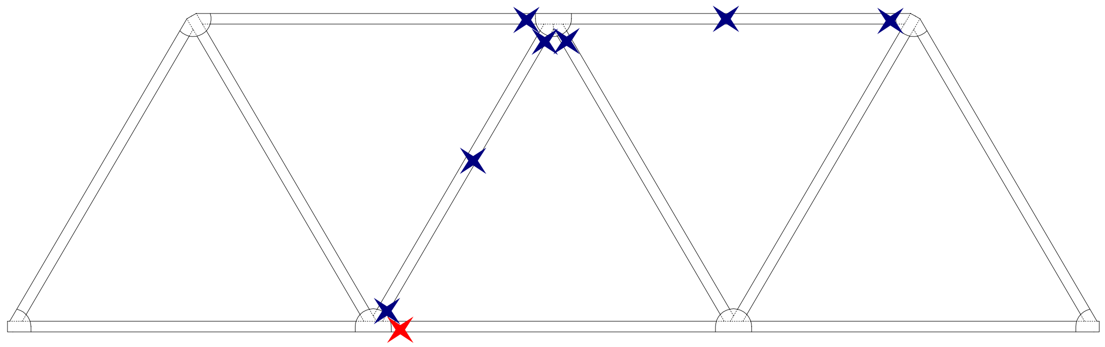
$$cf = \frac{2F}{\sqrt{3}}$$

Breaking Stress in First Member to Fail:

The member with the most force in it is *cf*. So we predicted that it would fail first.

The actual weight that caused it to fail was 35kg. So the tensile strength of 6mm square balsa is 396N. However this would not be true if the first member to fail was in compression, or if the truss failed first at a joint.

The first member to fail was unclear. Many members broke, and we couldn't see which members failed first. The position of breakages is shown below.



In total the truss failed in 8 different places. However many of these breakages resulted from one member initially failing. I suspect from the analysis of forces that the first member to break was the one in red.

Stress in the member that is thought to have broke first.

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{396.06}{0.000036} = 11.00\,\text{MPa}$$

Comparative Ratio:

$$\text{Comparative Ratio} = \frac{\text{load (kg)}}{\text{mass (kg)}} = \frac{35}{0.0241} = 1452.28$$

Conclusion:

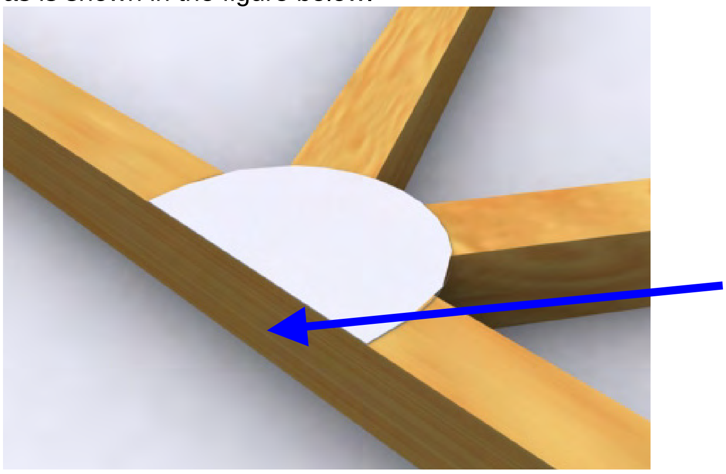
Member	Force at point of failure (N)	Nature
ad	198.03	Compression
ae	198.03	Compression
de	198.03	Tension
ef	198.03	Compression
fg	198.03	Compression
gb	198.03	Compression
bh	198.03	Compression
gh	198.03	Tension
ch	99.02	Tension
dc	99.02	Tension
cf	396.06	Tension

cf was the first member to break. It was in tension and it had a force of 396.06N acting on it. This stress in this member was 11.00GPa.

Recommendations:

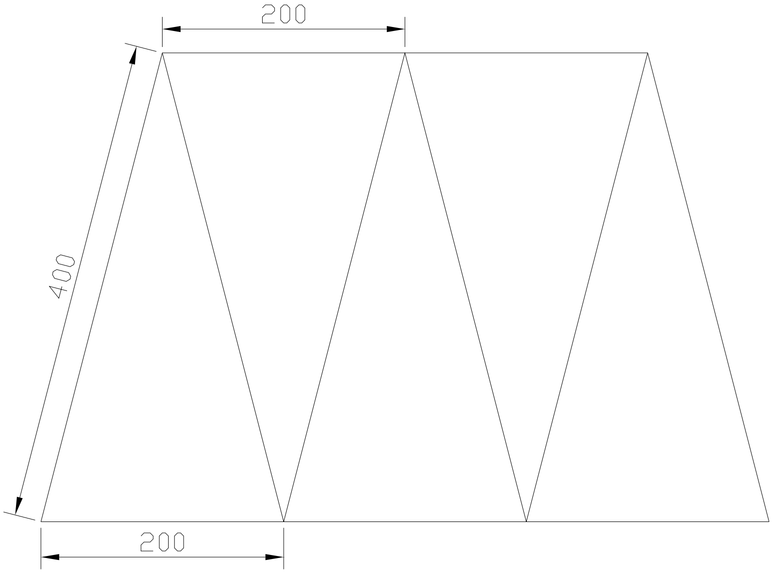
Although it is not likely that the break at joint BGH was the first breakage, that joint could have been manufactured better. This was the only break that was directly at the joint, as all the other breakages were either in the middle of a member or just outside where the gusset was attached. The gusset at joint BGH was the first one made, and it was not as good as the rest. This gusset didn't optimise the surface area available for gluing.

Also we could have applied more glue to the joints to make them stronger, and in places such as is shown in the figure below.

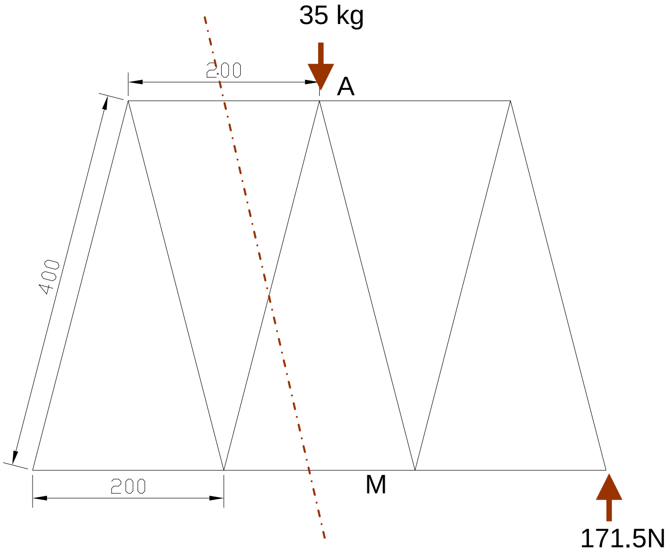


We could have added glue here, extending no further than the gusset. To strengthen the joint. However this may not have been allowed.

Alternate Height:



We also considered changing the height of the truss. By use of method of section the lower middle member had a force of 132.8N.



As shown by the section line, we ignore the parts on the left.

By taking moments about point A, we have 3 external forces acting on the truss. With only one unknown of the cental lower member, M.

$$\sum M_A^{\rightarrow +} = 0 = -(300 \times 171.5) + (387.30 \times M)$$

$$M = 132.8N \leftarrow (\text{Tension})$$

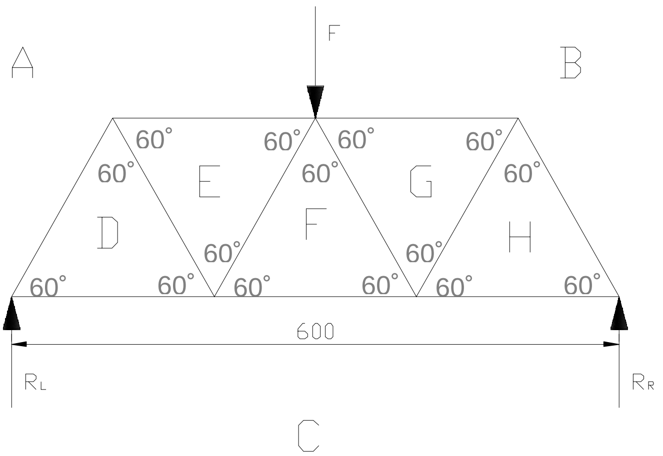
This is a less force compared with our actual design having 396.06N.

There was no height limit, so we could have made the truss higher, this would mean that it could have held a greater load before failure.

APPENDIX A

Design 1 (Warren Truss):

Free Body Diagram:



R_L and R_R can be calculated now. By looking at it you can see that $R_L = \frac{F}{2}$ and $R_R = \frac{F}{2}$. However for the sake of accuracy, these forces can be calculated, as shown below.

$$\sum M_{R_L}^{\rightarrow +} = 0 = -(0.6 \times R_R) + (F \times 0.3)$$

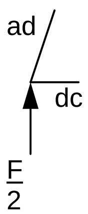
$$R_R = \frac{F \times 0.3}{0.6} = \frac{F}{2} \uparrow$$

$$\sum M_{R_R}^{\rightarrow +} = 0 = (0.6 \times R_L) - (F \times 0.3)$$

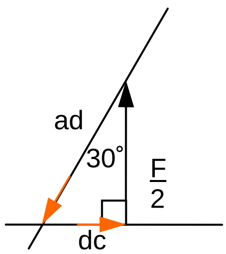
$$R_L = \frac{F}{2} \uparrow$$

The internal stresses can also be calculated.

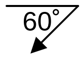
ADC:



Close up of Joint ADC



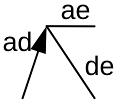
The R_L force is known in both magnitude and direction, so it is drawn in first. The forces in members' ad and dc are known in direction but not magnitude or sense. However, the sense can be obtained from the above force diagram, along with the magnitudes.

$$ad = \frac{F \div 2}{\cos 30°} = \frac{F}{\sqrt{3}}$$ 

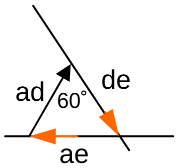
$$dc = \frac{F}{2}\tan 30° = \frac{F}{2\sqrt{3}} \rightarrow$$

ADE:

We know the forces in member ad, so the forces in members de and ae can be calculated.

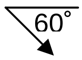


Close up of Joint ADE



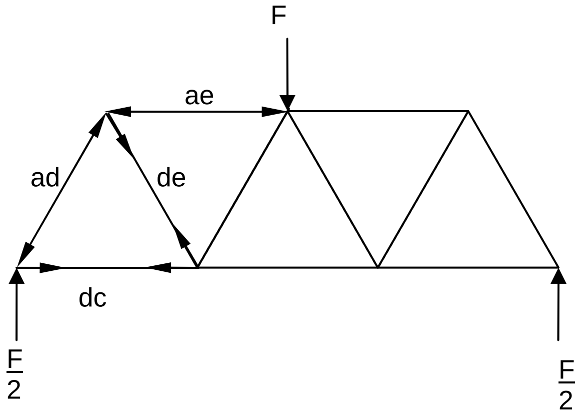
The forces in member ad are known in both magnitude and direction, so it is drawn in first. The forces in members' de and ae are known in direction but not magnitude or sense. However, the sense can be obtained from the above force diagram, along with the magnitudes.

de and ae are easily resolved. It is an equilateral triangle because all the internal angles are 60°, so ad = de = ae.

de 

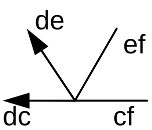
ae ←

So far the forces in the truss are as follows:

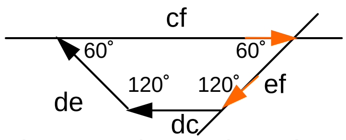


CDEF:

There are 4 members at joint CDEF. two of which are unresolved.

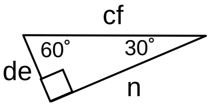


Close up of Joint CDEF.



The forces in members dc and de are known in both magnitude and direction, so they is drawn in first. The forces in members' ef and cf are known in direction but not magnitude or sense. However, the sense can be obtained from the above force diagram, along with the magnitudes.

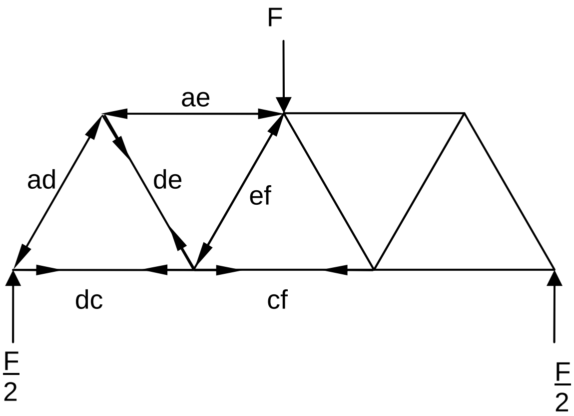
To resolve cf and ef, I have split this quadrilateral into two triangles. One of them is shown below.



$$cf = \frac{de}{\cos 60°} = 2 \times de$$

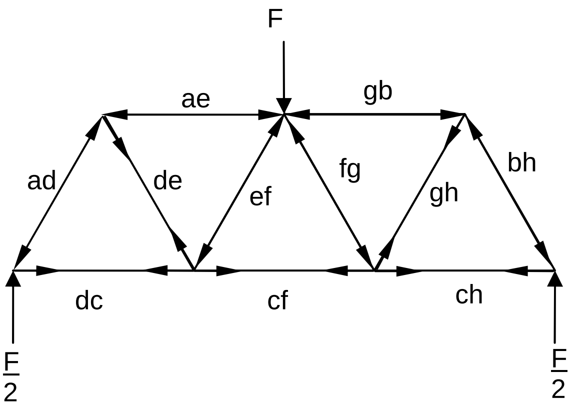
It can be seen that as the polygon is symmetrical ef = de.

So now the forces in the truss are as follows:



Final Analysis

As the truss is symmetrical, and the force is applied centrally, then we can assume the same forces for the other side of the truss.



(All triangles are equilateral (60˚ angles), and all members are 200mm.)

Where: (as previously calculated) (magnitudes only)

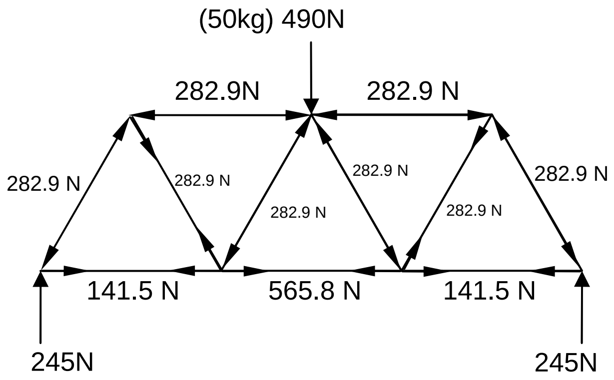
$$ad = ae = de = ef = fg = gb = bh = gh = \frac{F}{\sqrt{3}}$$

$$ch = dc = \frac{F}{2\sqrt{3}}$$

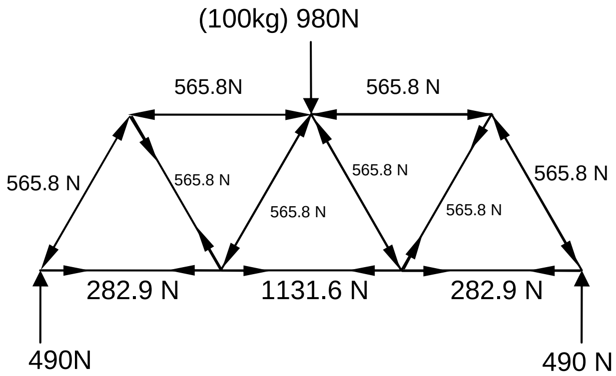
$$cf = \frac{2F}{\sqrt{3}}$$

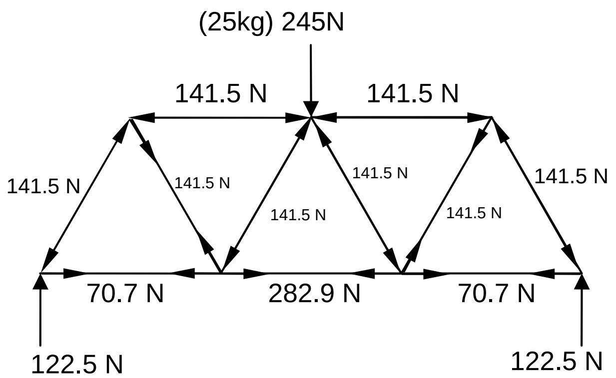
So with these results, I know which members are in tension and which are in compression (from the above diagram), and I can also work out the forces in each member given different masses applied at force F.

Now I could see how the truss would behave. I tested it with a 50kg mass applied centrally at the top. The forces I calculated are shown on the diagram below.



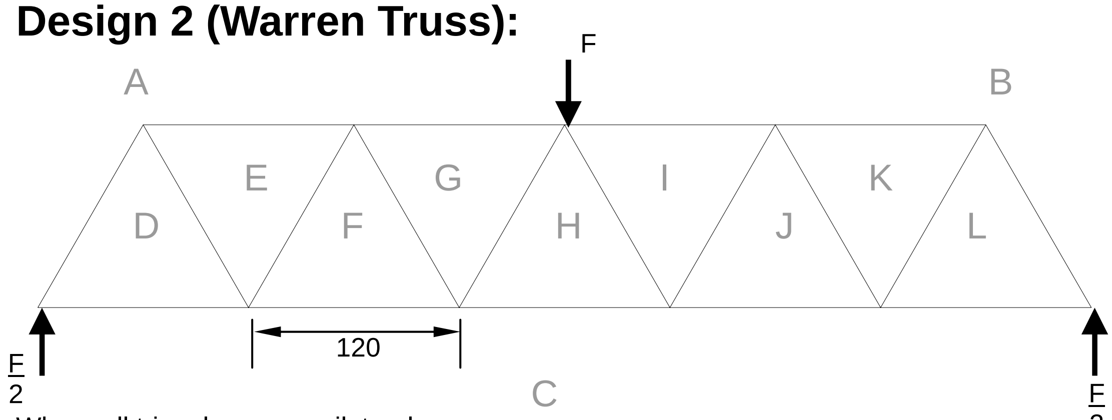
As there are 11 members, each being 0.2m long. The total amount of balsa used in this design is 2.2m. 3m of balsa weights 100g, so the 2.2m that was used in our truss design weighed 75g.





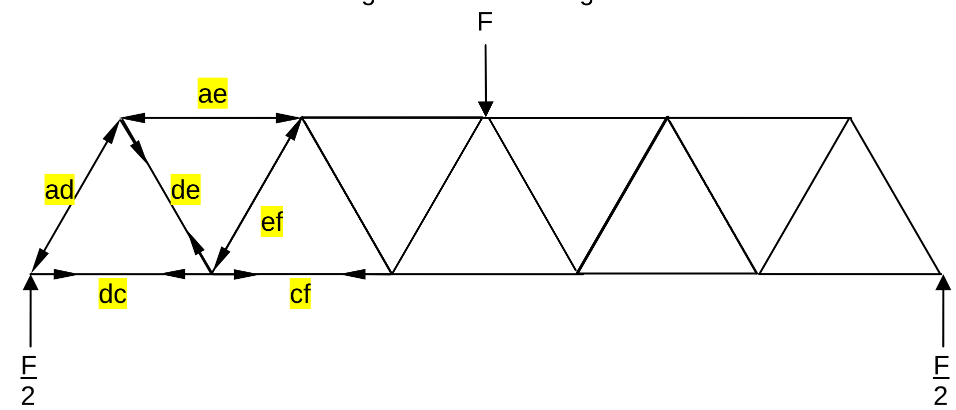
APPENDIX B

Design 2 (Warren Truss):



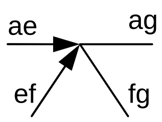
Where all triangles are equilateral.

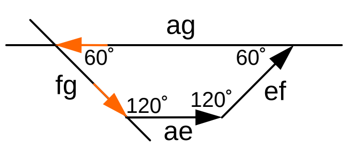
The forces in members ad, dc, ae, de, ef and cf have been calculated in design 1, and they are the same for this truss design. So the following forces are known.



AEFG

There are 4 members at joint AEFG. two of which are unresolved.





Free Body Diagram
Close up of Joint AEFG.

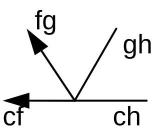
Force Diagram

$$fg = ef$$

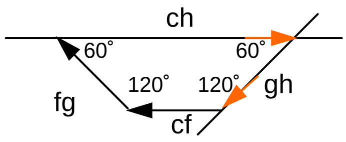
$$ag = \frac{2F}{\sqrt{3}}$$

CFGH

There are 4 members at joint CFGH. two of which are unresolved.



Free Body Diagram

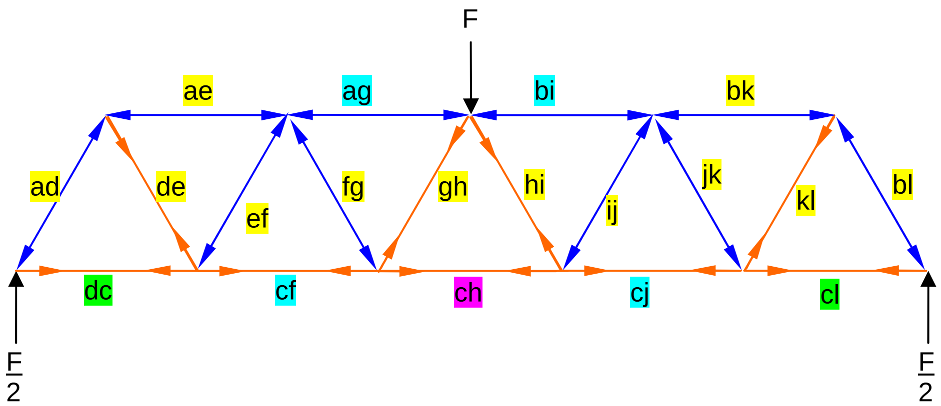


Force Diagram

$$gh = fg$$
$$ch = \frac{3F}{\sqrt{3}}$$

As the truss is symmetrical I can fill in the rest of it.

Final Analysis



$$\frac{F}{\sqrt{3}} = ad = ae = de = ef = fg = gh = hi = ij = jk = kl = bl = bk$$

$$\frac{F}{2\sqrt{3}} = dc = cl$$

$$\frac{2F}{\sqrt{3}} = cf = ag = bi = cj$$

$$\frac{3F}{\sqrt{3}} = ch$$

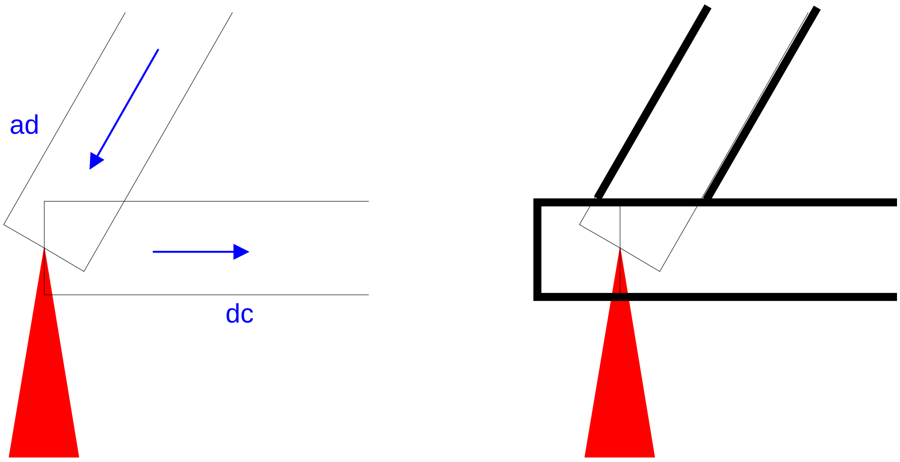
Case 1 (25kg)

141N
71N
283N
424N

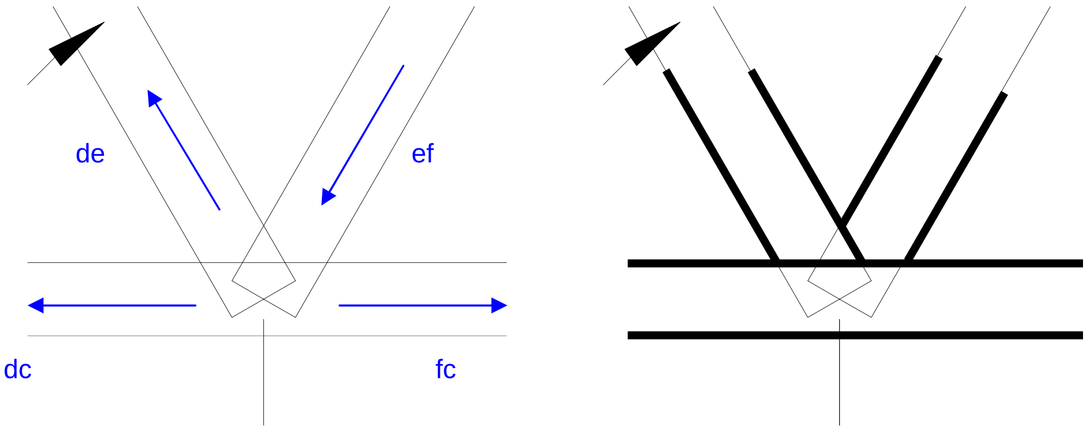
APPENDIX C – JOINTS

The joints are shown here. When we decided upon the joints we took into account whether the members were in tension or compression. We gave members in tension the greater surface area of gluing.

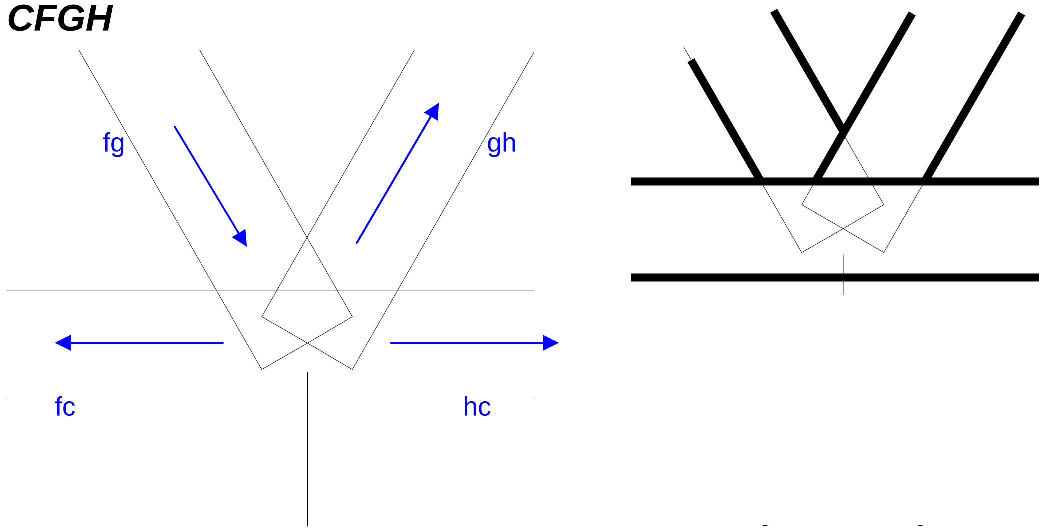
ADC



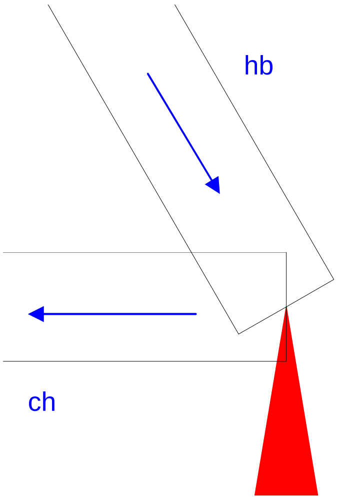
CDEF

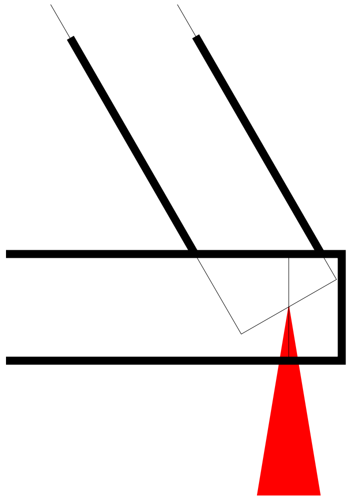


CFGH

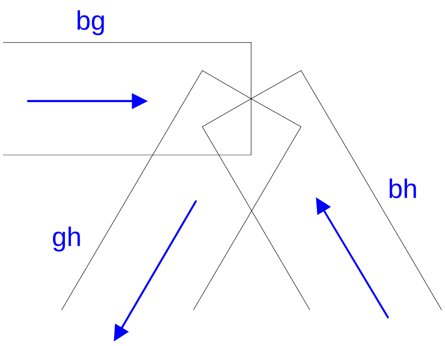


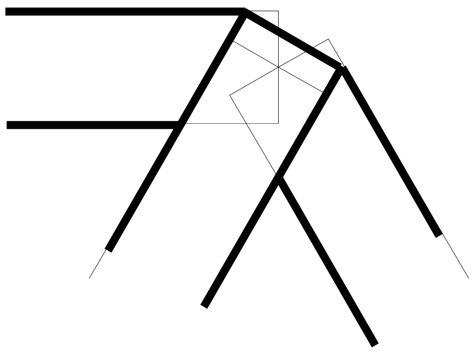
CHB



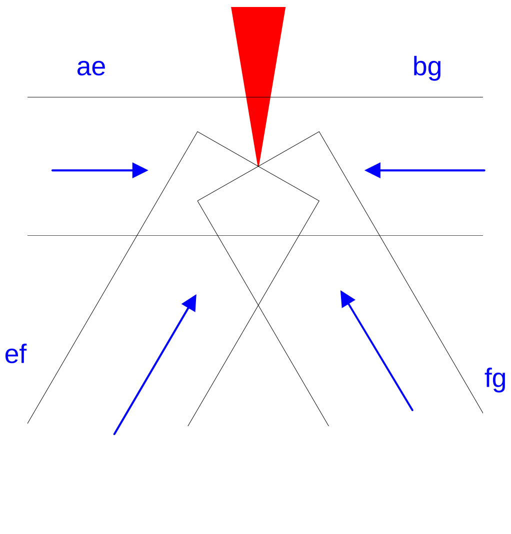


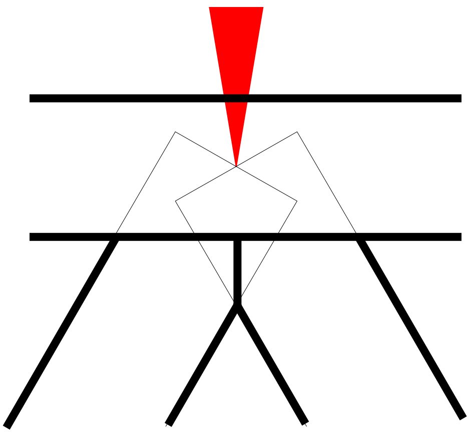
BGH



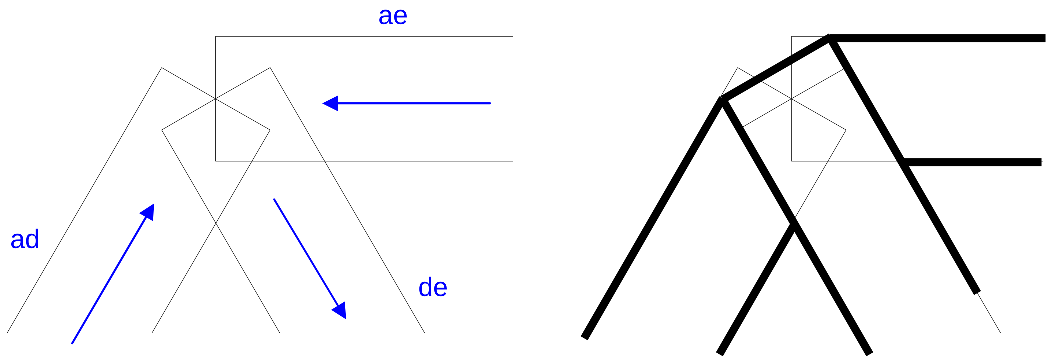


AEFGB





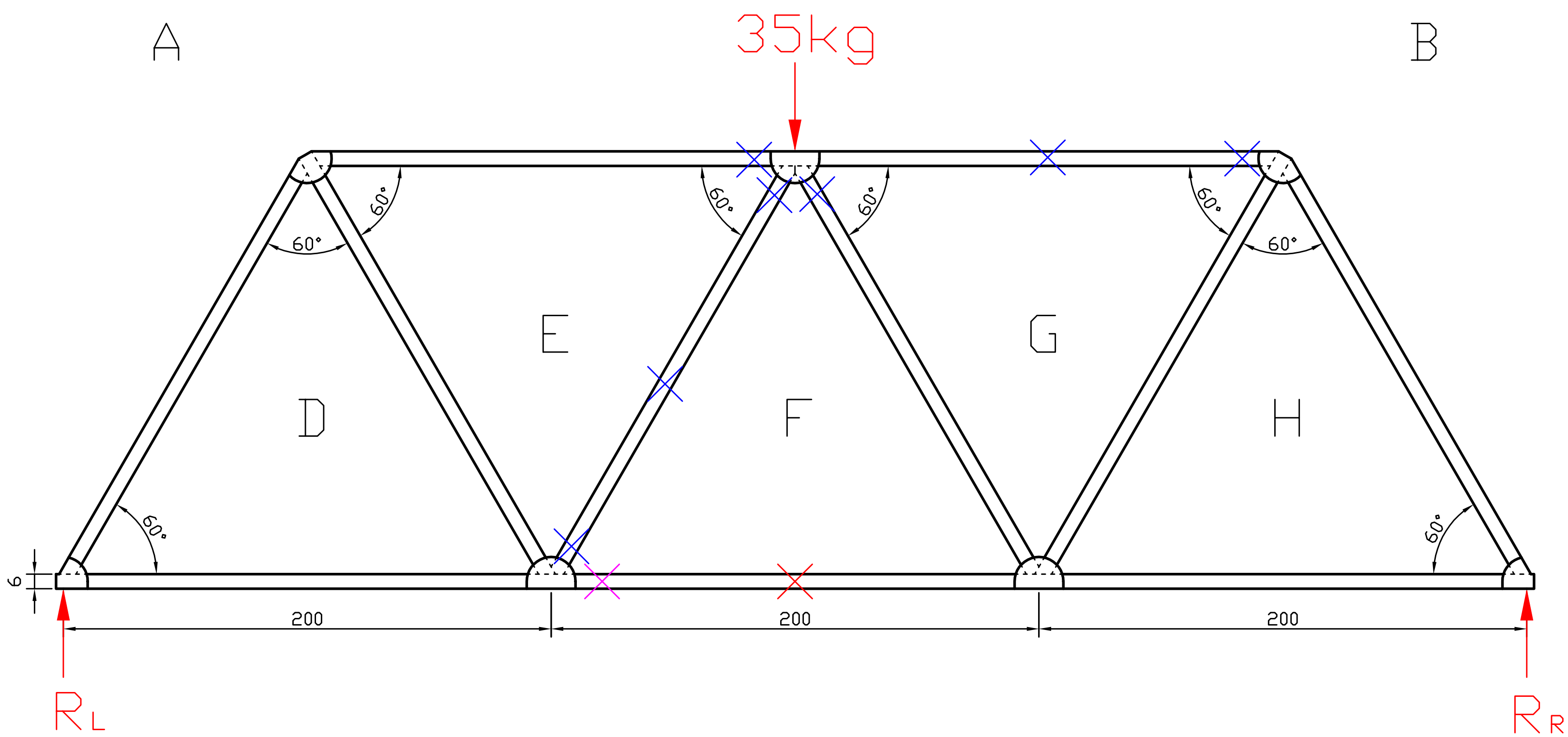
ADE



ALL MEMBERS ARE PIN JOINTED.
11 MEMBERS ARE IN USE, EACH 200mm IN LENGTH, 6mm SIDES, TOTALING 2.2m OF BALSA WOOD.

ALL TRIANGLES ARE EQULATERAL

- POSITION OF PREDICTED FAILURE (red ×)
- POSITION OF ACTUAL FAILURE (blue ×)
- POSITION OF 1st MEMBER TO FAIL (magenta ×)



ALL DIMENSIONS IN MILLIMETERS

DRAWING TITLE	PROJECT NAME	REVISION NO.	STANDARD
TRUSS ANALYSIS	E.S. - ASSESSMENT 1	1	AS1100

PROJECTION	STUDENT NAMES	DATE	SIZE	SCALE	DRAWING NO.
ORTHOGRAPHIC	ANDREW HARVEY &	22/11/06	A4	1:3	1